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envelope a spherical conic whose principal diametral arcs are  $2a$ , and  $2\beta$ ; they will pass through the fixed points, and the centre of the conic will be the pole of the great circle passing through the two fixed points.

12. The base of a spherical triangle being a quadrant, if its base angles  $a$ ,  $b$ , be such that  $\frac{\cot^2 a}{\tan^2 a} + \frac{\cot^2 \beta}{\tan^2 b} = 1$ , where  $a$  and  $\beta$  are given arcs, the locus of the vertex will be a spherical conic, whose principal diametral arcs are  $2a$ , and  $2\beta$ ; they will pass through the extremities of the given quadrant, and the centre of the conic will be the pole of the quadrant.

Some of the preceding theorems lead to new and very general properties of the conic sections: and one (No. 6) gives rise to a new and remarkably simple organic description of them. It should be observed that the arcs here spoken of are all arcs of great circles.

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His Grace the Archbishop of Dublin having taken the Chair, the President continued the reading of Dr. Robinson's Paper "On the Determination of the Constant of Refraction by Observations with the Mural Circle of the Armagh Observatory."

The author remarks, that the problem of astronomical refraction is embarrassed by two causes of error. The differential of the refraction is obtained by supposing the atmosphere to consist of spherical shells concentric with the earth; and the integral of this, by assuming some mathematical relation between the height above the earth and the corresponding density of the air. He shews that the first of these cannot be rigorously true; and that the relation between density and height, besides being unknown in general, may be expected to vary with the latitude. He therefore considers all existing refraction tables as approxi-

mations which require correction for each individual observatory.

For about  $74^\circ$  from the zenith, the refraction is independent of the law of density, and requires only an exact knowledge of the air's refractive power; this, however, has not been yet obtained with sufficient accuracy by direct experiment, and, therefore, must be deduced from astronomical observations. At greater zenith distances some constitution of the atmosphere must be assumed, and if its expression contain a sufficient number of arbitrary constants, the resulting refraction can always be made to represent with sufficient exactness what is actually observed. As, however, neither the formula of Bessel, nor that of Ivory, very readily admits such modifications, Dr. R. used the method given by the late Bishop of Cloyne, in the twelfth volume of the Royal Irish Academy's Transactions, which, however, he has extended to  $85^\circ$  zenith distance.

If the atmosphere be supposed of uniform temperature the refraction has been computed by Kramp; it is found greater than the truth. If the density be supposed to decrease uniformly as the height above the surface increases, the refraction is given by Simson; it is nearly as much in defect as the other in excess, and it is found that their mean is very near the truth. If then the differential equation of refraction be developed in terms of the tangent of the apparent zenith distance, it is found, on integrating, that the first term belongs to an atmosphere bounded by parallel planes; the second depends on the equilibrium of the strata, and the others alone are affected by the assumed hypotheses. Their geometrical means are found to satisfy the Armagh observations as far as  $85^\circ$  zenith distance, below which the series ceases to converge, and the mean changes its relation to the true refraction according to the temperature and pressure. The expression thus obtained for re-

fraction admits of being tabulated with the corrections for the thermometer and barometer in a couple of pages; and he thinks this form of tables more convenient than any other with which he is acquainted.

To compute them are required the expansion of air by heat; the ratio of the height of the homogeneous atmosphere to the radius of curvature of the meridian at the place of observation, and the refractive power of air at a given temperature and pressure. For the first he has used the value given by Rudberg, namely, that 1 of air at  $32^{\circ}$  becomes 1.365 at  $212^{\circ}$ . This differs from Gay Lussac, but is identical with that deduced by Bessel from astronomical observations. The second is derived from the researches of Arago and Biot, corrected for the change of gravity from Paris to Armagh.

Of the refractive power of air there are different values of high authority. Denoting by the symbol  $\mu$  the quantity  $\frac{\sin r - \sin R}{\sin R \times \sin 1''}$ , for  $50^{\circ}$  Fahrenheit and 29.60 inches pressure, the experiments of Arago and Biot give it 57.82. The observations of Delambre with a repeating circle give 57.72, which is also adopted by Brinkley. But the barometer used by this great astronomer is shewn by Dr. R. to require the correction  $+ 0.078$ , which would change the constant to 57.567; and as he also used the internal thermometer, perhaps a further diminution might be necessary. That of Bessel is 57.524, and that deduced by Dr. R. from his own observations is 57.546; but they cannot be exactly compared without a knowledge of the length of the pendulum at each station, as the measure of density given by the barometer depends on local gravity.

It was determined as follows by circumpolar stars. The refraction is obtained by subtracting from the subpolar distance  $270^{\circ}$  plus the declination observed above the pole. If the constant of refraction require a correction, it affects this

declination both at the star and at the polar point, and the latter also affects the subpolar observation; hence, calling the tabular refraction  $\mu v$ , and the difference between it and the observed  $dR$ , we have for each observation the equation of condition

$$dR = d\mu \{v - v' - 2P\} = d\mu \times K;$$

combining which by minimum squares, the value of  $d\mu$  for that star is obtained. If the values of it at different zenith distances are equal, or differ only by what may reasonably be considered error of observation, then it may be also inferred, that the formula correctly assigns the refraction through the range of zenith distance included by the observations.

Dr. R. then gives details respecting the mural circle which he used, the permanence of its microscopes as to *run*, and the mode of obtaining its index correction, and the correction of its divisions. When the stars are spectra, he bisects the yellow near the green, and remarks that the fluctuations of irregular refraction are often of considerable duration. The hygrometric state of the air does not seem to produce any effect, and he shews that the external thermometer is to be used at his observatory. The details of observation are then given for seventeen stars, from  $77^\circ 10'$  to  $84^\circ 56'$  zen. dist., of which there are 317 subpolar observations.

If a southern star be determined at a place when it passes near the zenith, so that its place may be assumed as free from error of refraction, the value of  $d\mu$  is multiplied by a much larger factor. This advantage, however, is more than balanced by the uncertainty caused by the difference of instruments and local circumstances at the two observatories; but Dr. R. has given the result of such a trial. He used the declinations of Mr. Johnson, (St. Helena Catalogue,) and, in many instances, those of Mr. Henderson at the Cape, and by 241 observations from  $77^\circ 53'$  to  $84^\circ 40'$  he found for  $\mu$  57.586; but conceives the result obtained from the northern

stars decidedly preferable, and has used it alone in computing the tables which are given at the end of the paper.

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DONATIONS.

*Proceedings of the Royal Academy of Berlin. July, 1838—January, 1840, with Index from 1836-39.* Presented by the Academy.

*Observations of the Magnetic Intensity in Europe.* By A. D. Bache, LL.D., &c. Presented by the Author.

*The Seventh Annual Report of the Royal Cornwall Polytechnic Society for 1839.* Presented by the Society.

*Natural History as a Branch of General Education.* Presented by the Natural History Society of Belfast.

*Proceedings of the Numismatic Society of London.* 1838, 1839. Presented by the Society.

*Proceedings of the American Philosophical Society.* No. 13. Presented by the Society.

*Flora Batava.* By Jan Kops. Nos. 120 and 121. Presented by the Author.

*Memoirs of the Royal Astronomical Society.* Vol. XI. Presented by the Society.

*Edinburgh Astronomical Observations.* Vol. III. 1837. Presented by the Royal Astronomical Society.

*On Paralytic, Neuralgic, and other Nervous Diseases of the Eye.* By Arthur Jacob, M.D. Presented by the Author.

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